2D Thomson scattering measurement of electron temperature and density in merging spherical tokamak plasmas

Seiyo Kobayashi[1], Haruka Yamaguchi[1], Jungkyun Kim[1], Shun Kamiya[1], Kei Yasoda[1], Muzuki Tanaka[1], Hiroshi Tanabe[1], and Yasushi Ono[1]

[1] Graduate School of Frontier Sciences, University of Tokyo

e-mail (speaker): skobayashi@ts.t.u-tokyo.ac.jp

Here we report our detailed investigation of electron heating during high guide field reconnection in TS-6 device using the novel cost-effective two-dimensional (2D) Thomson scattering measurement of electron temperature and density. As a cost-effective startup method of fusion reactors, the reconnection heating of spherical tokamak (ST) plasma merging has been studied in TS-6 (TS-3U) and other devices [1,2]. Figure 1 illustrates our novel Thomson scattering measurement system developed for TS-6. By use of multiple reflections and time-of-flight techniques [3], we achieved (i) 2D measurement with a single shot of Nd:YAG laser, and (ii) detection of scattered light from 17 × 7 (r - z) spatial channels using only 17 polychromators. Additionally, 2D profiles of the magnetic field and toroidal current density (j_t) were obtained using magnetic probes. As a post-MAST [4] detailed investigation of electron heating during high guide field reconnection, the first 2D measurement of electron temperature and density profile with magnetic diagnostics has been started.

Figure 2 shows the time scanning of 2D profile of electron temperature, electron density and toroidal current density during magnetic reconnection. The features are summarized as follows. First, the current sheet grew around x-point and electron started to accumulate in downstream region, while x-point pileup was not observed. This implies that, at this time, the current sheet could be driven by a small number of electrons with relatively high velocity. Second, the electron temperature and density around x-point and downstream region soared, which may indicate that the kinetic energy of the electron composing current sheet is converted to its thermal energy. Third, the accumulated electrons in downstream region spread along reconnected poloidal flux toward positive quadrupole potential area, which can be accelerated by the parallel electric field ($\vec{E}_{//} = E \cdot B/|B| \cdot \vec{e}_B$).

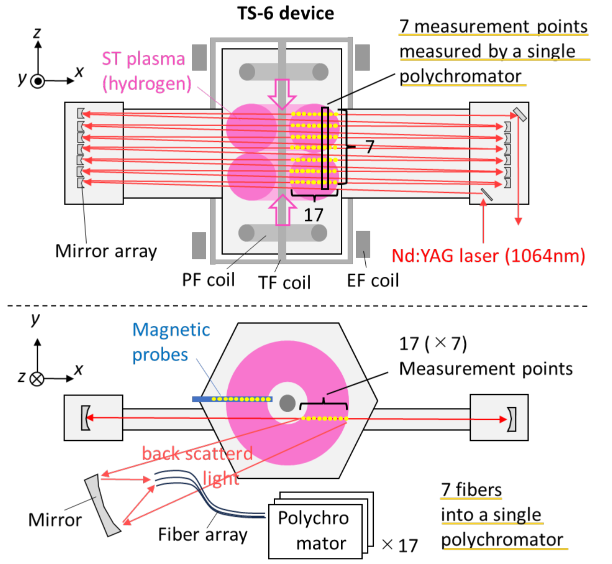

Figure 1. A schematic diagram of TS-6 device and the novel 2D Thomson scattering measurement system.

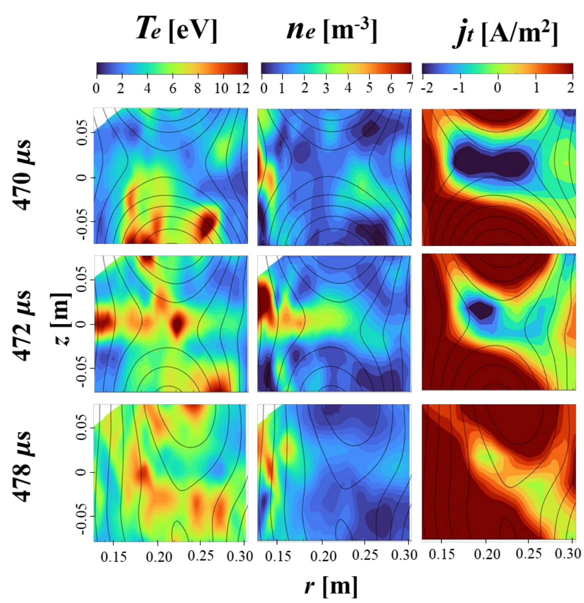

Figure 2. Observed 2D profile of electron temperature, electron density and toroidal current density during magnetic reconnection at time = 470, 472 and 478 μs. The black contour lines show the poloidal magnetic field (B_p).

References

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